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AUTHOR Niederhauser, Dale S.; Stoddart, Trish
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ABSTRACT

This study was conducted to examine how teachers' beliefs about computer-assisted instruction (CAI) relate to the types of instructional software they use with students, the types of computer related activities they provide for their students, whether they integrate computer usage with other instructional activities, and whether they had received training in various types of computer usage. Data were collected through a survey mailed to every public elementary, middle, junior high, and high school in one state. A total of 2,170 usable surveys (63 percent) were returned. The questionnaire contained items which focused on: teacher demographics; beliefs about the effectiveness of using computers in instruction; the amount, frequency, and type of CAI teachers engaged in; frequency of use; subject areas for software used; and the types of technology training they had received. According to the data analysis, teachers' beliefs about effective use of technology for instructional purposes can be differentiated into two discrete categories: some teachers believe that computers are tools that students use in collecting, analyzing, and presenting information, while others believe that computers are teaching machines that can be used to present information, give immediate reinforcement, and track student progress. In general, elementary school teachers favored a more transmission oriented view of how computers can be effectively used, while secondary teachers tended to favor a more constructivist view. (Contains 16 references.) (LL)

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Teachers' perspectives on computer-assisted instruction: Transmission versus construction of knowledge

Dale S. Niederhauser, University of Utah
Trish Stoddart, University of California at Santa Cruz

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Theoretical Framework

The current round of national reform efforts recommend a shift from teacher-directed transmission approaches to instruction towards student-centered conceptual approaches to teaching and learning which emphasize the social and cognitive construction of knowledge and the integration of advanced technology (American Association for the Advancement of Science, 1989; National Council of Teachers of Mathematics, 1989; National Science Teachers Association, 1990). Technology plays a key role in this new vision. It is commonly believed that microcomputers can be used to effectively develop student understanding and individualize instruction (Fuson & Brinko, 1985; Goldman, Pellegrino & Mertz, 1987; Resnick & Ford, 1981; Suppes & Morningstar, 1972). Simply installing computers in public school classrooms and labs, however, will not change teachers' approaches to instruction. The way teachers integrate the use of technology into their teaching will be strongly influenced by their beliefs about the role technology can play in their instructional practice.

Over the past decade, researchers have documented the powerful effect of teachers' personal beliefs on their teaching practices (Buchman 1988, 1989; Bullough, 1989; Hollingsworth, 1989; Lortie, 1975; Zeichner, Tabachnick & Densmore, 1987). Personal perspectives, based on prior life experiences, have been shown to serve as major pedagogical driving forces throughout teachers careers. Of particular importance is the "apprenticeship of observation"--the thousands of hours they spent as pupils in grade school classrooms (Lortie, 1975). Teachers tend to draw on their own experiences as learners and often seek to create in their teaching those conditions that were missing from their own education (Knowles & Holt-Reynolds, 1991).

The majority of the current teaching force, however, have little experience in learning through technology. They were educated in classrooms that were relatively "computer free" and have limited

personal experience to draw on in forming their perspectives on computer-assisted instruction (CAI). Thus, teachers look to the outside world for help, often relying on computer vendors to provide direction and training for the integration of technology into their classrooms. It is often a technology expert who chooses the software that is made available for teachers to use with students and provides training for teachers in the use of the software. In light of this, it is important to examine the relationship between teachers' beliefs about effective uses of CAI (ie. behavioral vs. constructivist) and the types of software (ie. Tutor, Tool, Tutee) that they use with students.

The present study will address how teachers beliefs about CAI relate to the types of instructic oftware they use, the types of computer related activities they provide for students, whether they integrate computer usage with other instructional activities and whether they had received training in various types of computer usage.

Method

Data Source

The data presented in this study were collected through a statewide study which examined teachers' usage of technology in their classrooms. A set of questionnaires was mailed to every public elementary, middle, junior high and high school in the State. Two teachers per grade level grouping (K-2, 3-4, 5-6) were surveyed at the elementary level while three teachers per grade level grouping (7-8, 9-10, 11-12) were surveyed at the middle, junior high and high school levels. A total of 2170 usable surveys were returned (63%).

Questionnaire

The survey contained items which focused on teacher demographics; their beliefs about effectiveness of using computers in instruction; the amount frequency and type of CAI teachers

engaged in; names, frequency of use, and subject areas for software they use; and the types of technology training they received.

Analysis of Teacher Belief Items

The questionnaire contained 18 items that evaluated teacher beliefs about CAI. Teachers rated how effective they believed computers to be in accomplishing a variety of goals such as "Introducing students to the subject," "Reinforcing each right answer," "Developing higher order thinking skills" and "Helping students to construct their own representations of concepts." Items were rated on a 5 point Likert scale in terms of how effective computers are when compared with more traditional forms of instruction (much less effective (1) to much more effective (5)).

The eighteen questionnaire items were entered into a Principal Component Analysis. The initial decomposition of the unadjusted correlation matrix extracted three factors with eigenvalues greater than 1 which accounted for 55.3% of the total variance in the matrix. Examination of a scree plot of the factors indicated that only two of the factors were viable. These two factors were retained and the factor matrix was rotated using the varimax method. The two factor orthogonal solution was theoretically meaningful and supported our decision to retain only two factors. These two factors accounted for 49.6% of the total variance in the matrix.

Two measures were used to examine the correlation matrix to determine if the data were appropriate for factor analysis techniques. Bartlett's test of sphericity was used to test the hypothesis that the correlation matrix is an identity matrix. The value of the test statistic for sphericity (Bartlett Test of Sphericity = 14089.800, $p < .001$) is large and the associated significance level is small, so it appears unlikely that the population correlation matrix is an identity. The Kaiser-Meyer-Olkin measure of sampling adequacy is an index for comparing the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients. In this analysis, the KMO value was .92880. Thus, correlations between pairs of variables can, to a large degree, be explained by the other variables. Both of these indicators suggest that a factor analysis is an appropriate technique to apply to these data.

Based on the five highest loading items on each factor, we developed labels for the factors. We named Factor 1 Student-centered Construction of Knowledge. This factor included the following identifying items:

Item 17:	Helping students to construct their own representations of concepts (.80001).
Item 16:	Allowing students to analyze data, draw inferences and generate their own problem solutions (.79705).
Item 12:	Promoting student creativity (.76510).
Item 14:	Providing experiences which enable students to discover concepts for themselves (.75075).
Item 10:	Developing higher order thinking skills (.73913).

We named Factor 2 Computer-centered Transmission of Knowledge. This factor included the following identifying items:

Item 18:	Providing students with practice in basic skills (.70999).
Item 7:	Making sure students get the right answer (.70089).
Item 13:	Providing drill and practice in the content required by the core curriculum (.68488).
Item 8:	Reinforcing each right answer (.68173).
Item 11:	Remediating student learning deficits (.57257).

Factor scores for each subject were computed using the regression method. These factor scores were used as an indication of how teachers believe computers can be effectively used in instruction for subsequent analyses.

Comparative and Correlational Analyses

Teachers were asked to list up to four software packages that they regularly used for instruction with students. These titles were coded and grouped into seven categories for analysis:

Drill and Practice/Traditional ILS	Math Blaster, Reader Rabbit, SRA Math, IBM Math Practice **(DP/ILS)**
Management Tools	Gradebook Plus, ICLAS **(TEACHER TOOLS)**
Keyboarding	Touchtyping, Typing Tutor **(KB)**
Interactive/Games	Carmen San Diego, Measurement, Time and Money **(INT/GAME)**
Productivity Tools	Wordperfect, MS Word, Lotus 123 **(TOOLS)**

Exploratory	Logo, Geometric Supposer, Math Exploration Toolkit (**EXPL**)
Presentation/Representation	Hypercard, Linkway (**PRES/REP**)

Software like DP/ILS, TEACHER TOOLS and KEYBOARDING were grouped together as they reflect a more traditional transmission type use of computers while the remaining more elaborated uses were grouped together as they can be used in more constructivist ways.

Individual teachers were assigned to groups based on whether they listed only software that reflects a traditional transmission orientation to CAI (DP/ILS, TEACHER TOOLS and KB), only software that can be used in more constructivist ways (INT/GAMES, TOOLS, EXPL and PRES/REP), or a combination of transmission and constructivist type software.

A series of analyses were conducted to examine the relationship between teachers beliefs and their practice. The first analysis examined differences between Elementary and Secondary teachers and the three software categories (transmission, constructivist and mixed) on the two factor scores (constructivist and transmission). In addition, factor scores were correlated with instructional activities that teachers use with computers and whether or not teachers had received training in specific instructional computing areas.

Results

The findings presented below analyze the relationship of teachers' beliefs about CAI to their classroom use of CAI and the training they have received for using computers in their classrooms.

Group Differences

A 3 x 2 x 2 Analysis of Variance (ANOVA) with Level (Elementary versus Secondary) and Software (Transmission, Mixed, Constructivist) as between subject factors and Orientation (Transmission, Constructivist) as a within subject factor. The two factor scores were used as dependent measures.

A main effect was found for Level ($F(1, 1561) = 7.67$, $p < .01$, $MS_e = .94942$), and for Software ($F(2, 1561) = 4.45$, $p < .05$, $MS_e = .94942$). Both of these results are mediated by the following interactions.

An effect was found for the Level x Orientation interaction ($F(1, 1561) = 18.53$, $p < .001$, $MS_e = .90233$). This result reflects the elementary teachers' factor scores being lower for Factor 1 (adj. $\underline{X} = -.12444$, $\underline{SD} = .99186$) than for Factor 2 (adj. $\underline{X} = .05532$, $\underline{SD} = .97216$) while Factor 1 scores for secondary teachers were higher (adj. $\underline{X} = .23567$, $\underline{SD} = .86590$) than were Factor 2 scores (adj. $\underline{X} = -.01936$, $\underline{SD} = .98697$). These results indicate that elementary teachers view computers as more effective for Teacher-centered Transmission type instruction (lower on factor 1, higher on factor 2) while the secondary teachers view computers as more effective for Student-centered Constructivist type instruction (higher on factor 1, lower on factor 2). See figure 1.

An additional effect was found for the Software x Orientation interaction ($F(2, 1561) = 14.76$, $p < .001$, $MS_e = .90233$). This result reveals that teachers who used Transmission software had lower scores for Factor 1 (adj. $\underline{X} = -.26752$, $\underline{SD} = .93963$) than for Factor 2 (adj. $\underline{X} = .08932$, $\underline{SD} = 1.01295$), teachers who used Mixed software had higher scores for Factor 1 (adj. $\underline{X} = .15100$, $\underline{SD} = .95175$) than for Factor 2 (adj. $\underline{X} = .03574$, $\underline{SD} = .90734$), and teachers who used Constructivist software had much higher scores for Factor 1 (adj. $\underline{X} = .28351$, $\underline{SD} = .89528$) than for Factor 2 (adj. $\underline{X} = .07111$, $\underline{SD} = 1.01841$). This result indicates that teachers beliefs about how computers can be used effectively (as indicated by their factor scores) is consistent with the type of software they report using in their classrooms. See figure 2.

A series of Pearson correlation analyses examined the relationship between the two factor scores and (1) the types of computer activities teachers use with their students and (2) the types of other instructional activities that teachers do along with computer activities in their classrooms. The matrix of correlation coefficients can be seen in tables 2 and 3.

Table 2: Correlation of factor scores with whether teachers provide specific computer related activities for their students.

Computer Activities	Constructivist Factor	Transmission Factor
Drill and practice software	-.0622**	.0941**
Word processing	.0762**	.0194
Interactive software	.0736**	.0224
Data management (database, spreadsheet)	.0663**	-.0241
Exploration tools (simulation, microworld)	.1049**	-.0023
Authoring programs	.0960**	-.0213
Programming languages	.0558*	-.0207
Class presentations	.0750**	-.0208
Access bulletin boards	.0684**	-.0240
Testing and assessment	.1098**	.0324
Graphics and design software	.0997**	.0160

Note. * = $p < .05$; ** = $p < .01$

As table 2 shows, the use of drill and practice software is the only variable that correlated significantly with the Computer-centered Transmission of Knowledge factor ($p < .01$). In contrast, The use of drill and practice software variable had a significant negative correlation with the Student-centered Construction of Knowledge factor ($p < .01$). All of the more elaborated uses of instructional computers (Word Processing through Graphics and Design Software) correlated significantly with the Student-centered Construction of Knowledge factor.

Table 3 indicates that Student-directed Small Group Activities, Hands-on Activities or Experiments, and Research Projects correlate significantly with the Student-centered Construction of Knowledge factor while Review or Remediation correlated significantly with the Computer-centered Transmission of Knowledge factor and Homework or Seatwork Activities correlated with both factors.

Table 3: Correlation of factor scores with whether teachers integrate computer usage with other instructional activities.

Computer Activities	Constructivist Factor	Transmission Factor
Student-directed small group activities	.1263**	.0280
Homework or seatwork exercises	.0585*	.0830**
Review or remediation	-.0208	.1500**
Hands-on activities or experiments	.2103**	.0190
Research projects	.1647**	-.0021

Note. * = $p < .05$; ** = $p < .01$

Staff development

Finally, we examined the relationship between the factor scores and whether or not teachers had received training in specific instructional computing areas (see table 4). On the Student-centered Construction of Knowledge factor, a pattern emerges that somewhat resembles the analysis presented in table 2.

Table 4: Correlation of factor scores with whether teachers received inservice training in specific areas.

Inservice Topics	Constructivist Factor	Transmission Factor
Drill and practice software	-.0637**	.0473*
Word processing	.0455*	.0455*
Interactive software	.0680**	.0270
Data management (database, spreadsheet)	.1090**	.0331
Exploration tools (simulation, microworld)	.1200**	.0282
Authoring programs	.1917**	.0237
Programming languages	.0700**	.0484*
Instructional presentations	.0804**	.0621**
Accessing bulletin boards	.0786**	.0013
Testing and assessment	.0795**	.1013**
Graphics and design software	.0944**	.0693**

Note. * = $p < .05$; ** = $p < .01$

Receiving training in Drill and Practice software correlated in a negative direction while training in the more elaborated uses all correlated positively. On the Computer-centered Transmission of Knowledge factor, receiving training in Drill and Practice Software was positively correlated, as were training in Word Processing, Programming Languages, Instructional Presentations, Testing and Assessment, and Graphics and Design Software.

Discussion

These results indicate that teachers' beliefs about how technology can be effectively used in instruction can be differentiated into two discrete categories. Some teachers believe that computers are tools that students use in collecting, analyzing and presenting information, while others believe that

computers are teaching machines that can be used to present information, give immediate reinforcement and track student progress. In addition, teachers' beliefs about effective uses of computers are closely linked with their use of computers in the classroom. Teachers who used more open ended, constructivist type software with their students believed that computers can be used more effectively as a tool for student construction of knowledge while teachers who used more traditional behaviorist types of software believed that computers were effective as teaching machines. However, there are no guarantees that teachers are **using** the software in the ways indicated here. It is possible to use constructivist type software in transmission oriented ways (ie. having students type in a teacher designed Logo program) and transmission type software can be used in more constructivist ways (ie. having students design multiple choice tests for their peers based on a research project). Further research using interview and observation techniques would illuminate this issue.

Furthermore, it is not clear whether teachers beliefs about effective uses of computers influenced the purchase of software in their schools, or whether the software that was purchased (and training teachers received) influenced teachers beliefs about how computers can be effectively used. In fact, evidence suggests that teachers frequently play minor roles in the selection of hardware and software that is used in their schools (Mergendoller, Stoddart, Horan, Niederhauser, & Bradshaw, 1992). How these attitudes develop would merit further study.

In general, elementary school teachers tend to favor a more transmission oriented view of how computers can be effectively used in the education of their students while secondary teachers tend to favor a more constructivist view. This may be due to the fact that there is more skill and drill oriented software available for elementary school age students. The major producers of Integrated Learning Systems like Jostens Learning and Wasatch Education Systems have been developing and refining K - 6 software for many years. These companies have been successful in marketing their products and philosophy in elementary schools for several years, perhaps they have been less successful with secondary schools.

The largest group of teachers said they used both types of software and this group was positioned between the other two groups with respect to the student-centered constructivist factor but

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was more closely aligned with the traditional transmission group on the computer-centered transmission factor. It would be of interest to monitor this group to see if they move toward the constructivist or transmission end of the continuum.

There was a correlation between the student construction factor and more integrated uses of computers with students. In examining the relationship between teacher perspectives on CAI and instructional use, we observed that teachers who believed that CAI was most effectively used for student construction of knowledge were more likely to say they used computers in ways that go beyond traditional "teaching machine" uses of computers. These teachers provided a wide variety of activities for their students and were able to integrate computer applications. It is not surprising that these teachers also received training in these areas, however, the direction of this relationship is not clear, i.e., whether training influenced beliefs or whether their beliefs prompted teachers to seek out training. In contrast, there was a relationship between the transmission factor and using the computer for homework or seatwork and review or remediation. These types of activities are typically supported by the software typically found in an ILS.

Teachers' beliefs that computers were most effective for student construction of knowledge tended to reflect training in more elaborated uses of technology and reported a variety of uses in their classrooms. Teachers who had higher constructivist factor scores had not had extensive training in the use of drill and practice software and tended not to use it in their teaching. The relationship between training and use of technology with students on the student-centered constructivist factor (tables 2 & 4) is striking. Once again, further study is needed to determine the direction of this relationship.

As might be expected there was an association between teachers' who had higher scores on the computer-centered transmission factor and the drill and practice computer activities that they chose to use with students and the training they had received. It is of interest that although there was a relationship between the transmission factor and receiving training in using drill and practice software, word processing, programming languages, instructional presentations, testing and assessment and graphics and design software, only the drill and practice software correlated with activities with students. These other activities are, however, consistent with the transmission view of

instruction. Computer programming is often taught through traditional transmission techniques. Instructional presentation software can be used as an electronic blackboard. Word processing and graphics/design programs can be used for preparing handouts, tests and other instructional materials, and testing and assessment programs are often included in ILS programs.

Although these correlation values are rather modest, they reveal an interesting pattern of relationships. The findings of this study indicate that teachers' beliefs about CAI are associated with their use of technology in instruction. One interpretation of the staff development data is that the training that teachers receive may have a powerful influence on their beliefs about how technology can be effectively used in education.

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